

CLAIMS

1. Process for producing an epoxidized elastomeric polymer comprising:
  - feeding at least one elastomeric polymer containing ethylenic unsaturations to a mixing device;
  - feeding at least one hydrogen peroxide precursor to said mixing device;
  - feeding at least one carboxylic acid or a derivative thereof to said mixing device;
  - mixing and reacting, in the presence of water, said at least one elastomeric polymer containing ethylenic unsaturations, with said at least one hydrogen peroxide precursor and said at least one carboxylic acid or a derivative thereof, to obtain an epoxidized elastomeric polymer;
  - discharging the resulting epoxidized elastomeric polymer from said mixing device.
2. Process for producing an epoxidized elastomeric polymer according to claim 1, wherein the mixing device is selected from: open internal mixers; internal mixers; continuous mixers of Ko-Kneader type; co-rotating or counter-rotating twin-screw extruders.
3. Process for producing an epoxidized elastomeric polymer according to claim 2, wherein the mixing device is a co-rotating twin-screw extruder.
4. Process for producing an epoxidized elastomeric polymer according to any one of the preceding claims, wherein the elastomeric polymer containing ethylenic unsaturation is fed to the mixing device in a solid form.
5. Process for producing an epoxidized elastomeric polymer according to any one of the preceding claims, wherein the hydrogen peroxide precursor is

fed to the mixing device in a solid form.

6. Process for producing an epoxidized elastomeric polymer according to any one of the preceding claims, wherein said process is carried out at a 5 temperature of between 15°C and 200°C.

7. Process for producing an epoxidized elastomeric polymer according to claim 6, wherein said process is carried out at a temperature of between 50°C and 180°C.

10 8. Process for producing an epoxidized elastomeric polymer according to any one of the preceding claims, wherein said process is carried out for a time of between 10 seconds and 30 minutes.

9. Process for producing an epoxidized elastomeric 15 polymer according to claim 8, wherein said process is carried out for a time of between 30 seconds and 20 minutes.

10. Process for producing an epoxidized elastomeric polymer according to any one of the preceding 20 claims, wherein the obtained epoxidized elastomeric polymer contains less than 10 mol% of epoxy groups relative to the total number of moles of monomers present in the elastomeric polymer.

11. Process for producing an epoxidized elastomeric 25 polymer according to claim 10, wherein the obtained epoxidized elastomeric polymer contains from 0.1 mol% to 5 mol% of epoxy groups relative to the total number of moles of monomers present in the elastomeric polymer.

30 12. Process for producing an epoxidized elastomeric polymer according to any one of the preceding claims, wherein the elastomeric polymer containing ethylenic unsaturations is selected from diene homopolymers or copolymers having a glass 35 transition temperature ( $T_g$ ) below 20°C.

13. Process for producing an epoxidized elastomeric

polymer according to claim 12, wherein the elastomeric polymer containing ethylenic unsaturations is selected from: cis-1,4-polyisoprene, 3,4-polyisoprene, polybutadiene, 5 optionally halogenated isoprene/isobutene copolymers, 1,3-butadiene/acrylonitrile copolymers, styrene/1,3-butadiene copolymers, styrene/isoprene/1,3-butadiene copolymers, styrene/1,3-butadiene/acrylonitrile copolymers, or 10 mixtures thereof.

14. Process for producing an epoxidized elastomeric polymer according to any one of claims 1 to 11, wherein the elastomeric polymer containing ethylenic unsaturations is selected from 15 elastomeric polymers of one or more monoolefins with an olefinic comonomer and at least one diene, or derivatives thereof.

15. Process for producing an epoxidized elastomeric polymer according to claim 14, wherein the 20 elastomeric polymer containing ethylenic unsaturations is selected from: ethylene/propylene/diene copolymers (EPDM); polyisobutene; butyl rubbers; halobutyl rubbers; or mixtures thereof.

25 16. Process for producing an epoxidized elastomeric polymer according to any one of the preceding claims, wherein the elastomeric polymer containing ethylenic unsaturations has an average molecular weight between 2000 and 1,000,000.

30 17. Process for producing an epoxidized elastomeric polymer according to any one of the preceding claims, wherein the hydrogen peroxide precursor is selected from:

35 (a) inorganic persalts;

(b) metal peroxides;

(c) hydrogen peroxides adducts.

18. Process for producing an epoxidized elastomeric polymer according to claim 17, wherein the inorganic persalts (a) are selected from:

5 - boron compounds such as perborates, said perborates being selected from: sodium perborate hexahydrate of the formula  $Na_2[B(O_2)_2(OH)_4] \cdot 6H_2O$  (also defined as sodium perborate tetrahydrate of the formula  $NaBO_3 \cdot 4H_2O$ ); sodium peroxyborate tetrahydrate of the formula  $Na_2B_2(O_2)_2[(OH)_4] \cdot 4H_2O$  (also defined as sodium perborate trihydrate of the formula  $NaBO_3 \cdot 3H_2O$ ); sodium peroxyborate of the formula  $Na_2[B_2(O_2)_2(OH)_4] \cdot 4H_2O$  (also defined as sodium perborate monohydrate of the formula  $NaBO_3 \cdot H_2O$ ); or mixtures thereof;

10 - alkali metal percarbonates such as sodium percarbonate (sodium carbonate peroxyhydrate); potassium percarbonate; rubidium percarbonate; cesium percarbonate; or mixtures thereof;

15 - persulfuric salts such as sodium persulfate, potassium peroxymonosulfate (also defined as potassium monopersulfate); or mixtures thereof.

19. Process for producing an epoxidized elastomeric polymer according to claim 17, wherein the metal peroxides (b) are selected from: lithium peroxide, sodium peroxide, magnesium peroxide, calcium peroxide, strontium peroxide, barium peroxide, zinc peroxide, or mixtures thereof.

20. Process for producing an epoxidized elastomeric polymer according to claim 17, wherein the hydrogen peroxide adducts (c) are selected from: urea/hydrogen peroxide adduct, polyvinyl pyrrolidone/hydrogen peroxide adduct, or mixtures thereof.

30 35 21. Process for producing an epoxidized elastomeric polymer according to any one of the preceding

claims, wherein the hydrogen peroxide precursor (b) is added in an amount of from 0.1 phr to 50 phr.

22. Process for producing an epoxidized elastomeric polymer according to claim 21, wherein the hydrogen peroxide precursor (b) is added in an amount of from, preferably from 0.5 phr to 20 phr.

5 23. Process for producing an epoxidized elastomeric polymer according to any one of the preceding claims, wherein the the carboxylic acid is selected from monocarboxylic acids or dicarboxylic acids.

10 24. Process for producing an epoxidized elastomeric polymer according to claim 23, wherein the monocarboxylic acids have the following general formula (I):

15 R-COOH (I)

wherein R represents a linear or branched C<sub>1</sub>-C<sub>12</sub> alkyl group; a C<sub>6</sub>-C<sub>18</sub> aryl group; a C<sub>7</sub>-C<sub>20</sub> arylalkyl or alkylaryl group; a C<sub>5</sub>-C<sub>18</sub> cycloalkyl group.

25 25. Process for producing an epoxidized elastomeric polymer according to claim 23, wherein the dicarboxylic acids have the following general formula (II):

HOOC-R<sub>1</sub>-COOH (II)

wherein R<sub>1</sub> represents a linear or branched C<sub>1</sub>-C<sub>12</sub> alkylene group; a linear or branched C<sub>2</sub>-C<sub>12</sub> alkenylene group; a C<sub>6</sub>-C<sub>18</sub> arylene group; a C<sub>7</sub>-C<sub>20</sub> alkylarylene or alkylenearylene group; a C<sub>6</sub>-C<sub>20</sub> cycloalkylene group.

30 26. Process for producing an epoxidized elastomeric polymer according to any one of the preceding claims, wherein the carboxylic acid derivative is selected from esters, anhydrides, halides, imides, amides, or mixtures thereof.

35 27. Process for producing an epoxidized elastomeric polymer according to claim 26, wherein the carboxylic acid derivative is selected from

anhydrides such as maleic anhydride, succinic anhydride, phthalic anhydride, or mixtures thereof.

28. Process for producing an epoxidized elastomeric polymer according to any one of the preceding 5 claims, wherein the carboxylic acid or a derivative thereof is added in an amount of from 0.1 phr to 50 phr.

29. Process for producing an epoxidized elastomeric 10 polymer according to claim 28, wherein the carboxylic acid or a derivative thereof is added in an amount of from 0.5 phr to 20 phr.

30. Process for producing an epoxidized elastomeric 15 polymer according to any one of the preceding claims, wherein at least one non-ionic surfactant is added.

31. Process for producing an epoxidized elastomeric 20 polymer according to claim 30, wherein the non-ionic surfactant is selected from those having a polyalkylene oxide polymer as a portion of the surfactant molecule such as chlorine-, benzyl-, methyl-, ethyl-, propyl-, butyl-, and other like alkyl-capped polyethylene and/or polypropylene glycol ethers of fatty alcohols; polyalkylene 25 oxides free non-ionic such as alkyl polyglycosides; polyol esters such as sorbitan esters, sucrose esters, or pentaerythritol esters and their ethoxylates; alkoxylated ethylene diamines; carboxylic acid esters such as glycerol esters, polyoxyethylene esters, ethoxylated and glycol 30 esters of fatty acids; carboxylic amides; ethoxylated amines and ether amines; or mixtures thereof.

32. Process for producing an epoxidized elastomeric 35 polymer according to claim 30, wherein the non-ionic surfactant is selected from C<sub>6</sub>-C<sub>24</sub> alcohol ethoxylates, having from 1 to about 20 ethylene

oxide groups; C<sub>6</sub>-C<sub>24</sub> alkylphenol ethoxylates having from 1 to about 100 ethylene oxide groups; C<sub>6</sub>-C<sub>24</sub> alkylpolyglycosides having from 1 to about 20 glycoside groups; C<sub>6</sub>-C<sub>24</sub> fatty acid ester 5 ethoxylates, propoxylates, or glycerides; C<sub>4</sub>-C<sub>24</sub> mono or dialkanolamides; or mixtures thereof.

33. Process for producing an epoxidized elastomeric polymer according to claim 30, wherein the non-ionic surfactant is selected from alcohol 10 alkoxylates including alcohol ethoxylate propoxylates, alcohol propoxylates, alcohol propoxylate ethoxylate propoxylates, alcohol ethoxylate butoxylates, or mixtures thereof; nonylphenol ethoxylate, polyoxyethylene glycol 15 ethers, or mixtures thereof; polyalkylene oxide block copolymers including an ethylene oxide/propylene oxide block copolymer, or mixtures thereof.

34. Process for producing an epoxidized elastomeric 20 polymer according to any one of claims 30 to 33, wherein the non-ionic surfactant is added in an amount of from 0 phr to 20 phr.

35. Process for producing an epoxidized elastomeric polymer according to claim 34, wherein the non- 25 ionic surfactant is added in an amount of from 0.1 phr to 10 phr.

36. Process for producing an epoxidized elastomeric polymer according to any one of the preceding 30 claims, wherein at least one stabilizing agent is added.

37. Process for producing an epoxidized elastomeric polymer according to claim 36, wherein the 35 stabilizing agent is selected from hindered phenols, sterically hindered amines, amine derivatives, dihydroquinoline derivatives, or mixtures thereof.

38. Process for producing an epoxidized elastomeric polymer according to claim 36 or 37, wherein the epoxy groups stabilizing agent is added in an amount of from 0 phr to 10 phr.
- 5 39. Process for producing an epoxidized elastomeric polymer according to claim 38, wherein the epoxy groups stabilizing agent is added in an amount of from 0.1 phr to 5 phr.
- 10 40. Process according to any one of the preceding claims, wherein the water is added in an amount of from 0.1 phr to 50 phr.
41. Process according to claim 40, wherein the water is added in an amount of from 0.5 phr to 20 phr.